Remarks

Claims 112-141 are pending in the Application.

Claim 125, 134-135, and 138-140 stand allowed.

Claims 112-124, 126-133, and 136-137 stand rejected.

Claim 141 is objected to.

Claims 138 and 141 are amended herein.

I. REJECTIONS UNDER 35 U.S.C. § 102/103 OVER *KIANG*

Claims 112, 114, 116, 118, 122-124, 127, 129, 131 and 136-137 stand rejected under 35 U.S.C. § 102(a) as being anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over, *Kiang et al.*, "Carbon Nanotubes with Single-Layer Walls," Carbon, 33(7), pp. 903-914, 1995 ("*Kiang*"). Office Action at 3. Applicant respectfully traverses these rejections.

Anticipation requires each and every element of the claim to be found within the cited prior art reference. To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *See* M.P.E.P. 706.02(j); *see also In re Vaeck,* 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

Regarding Claims 112, 114, 116, 118, 122-124, 127, 129, 131 and 136-137, the Examiner contends that "*Kiang* teaches that single-walled nanotubes tend to aggregate into bundles. The nanotubes in a bundle run substantially parallel to one another (see Figure 2c). No difference is seen between the bundles of *Kiang et al.* and the arrays of the instantly claimed invention." Office Action at 3.

Base Claims 112 and 124 recite "a substantially two-dimensional array comprising single-wall carbon nanotubes." First of all, regarding any three-dimensional structure, such as an array, as "substantially two-dimensional," one of ordinary skill in the art would appreciate a geometry wherein the dimensions of the structure in two directions substantially exceed the dimensions of the array in the third direction. A common example of a substantially two-dimensional structure is a piece of paper.

Second, regarding the element of an "array', the first definition of "array," given in "The American Heritage Dictionary," Second College Edition (1982), is "an orderly arrangement." (*See* Exhibit A.)

The bundles of *Kiang* appear as ropes of nanotubes and appear to one of ordinary skill in the art as a substantially **one-dimensional** structure, not "substantially two-dimensional" as required by Claims 112 and 124. Furthermore, the bundles of *Kiang* are deposited on chamber walls randomly, not in "an orderly arrangement" as an array.

With regard to Figure 8, Applicant presents this figure as a "schematic representation" (*See* Application at p. 6, ll. 29-30). Together with the description in the Application, one of ordinary skill in the art would recognize this schematic as a side view of one edge of a two-dimensional plane. The description in the Application give embodiments of "a substantially two-dimensional array," such as "a substantially two-dimensional array made up of single-walled nanotubes aggregating (e.g., by van der Waals forces) in substantially parallel orientation to form a monolayer extending in directions substantially perpendicular to the orientation of the individual nanotubes," (Application at page 38, ll. 25-30 and further on page 39, ll 1-23). Furthermore, the term "monolayer" is indicative of a "two-dimensional array" structure. Thus, in light of the description in the Application, one of ordinary skill in the art would recognize Figure 8 represents a side view of one edge of a two-dimensional plane.

In contrast, *Kiang* broadly describes bundles of nanotubes, none of which are in an orderly arrangement, nor are these bundles "substantially two-dimensional arrays." As stated above, *Kiang* discloses "substantially one-dimensional" structures and that are randomly arranged. *Kiang* does not teach or suggest substantially two-dimensional arrays comprising

single-wall carbon nanotubes. Accordingly, base Claims 112 and 124 would not be anticipated by, or obvious over, *Kiang*.

Regarding Claims 114, 116, 118, 122-123, 127, 129, 131 and 136-137, these claims depend from Claim 112 or claim 124, and, therefore, are also not anticipated or obvious for the same reasons that Claims 112 and 124 are not anticipated or obvious. As a result of the foregoing, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 112, 114, 116, 118, 122-124, 127, 129, 131 and 136-137 under 35 U.S.C. § 102(a) as being anticipated by, or in the alternative under 35 U.S.C. § 103(a), as being obvious over, *Kiang*.

II. REJECTIONS UNDER 35 U.S.C. § 102 OVER *KIANG* WITH *DRESSELHAUS* TO SHOW A STATE OF FACT

Claims 113, 115, 117, 119, 126, 128, 130, and 132 stand rejected under 35 U.S.C. § 102(a) as being anticipated by *Kiang*, as applied above and with Dresselhaus *et al.*, Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, 2001, Springer, pp. 3-6 and 73-75 ("*Dresselhaus*")[1] to show a state of fact.[2] Office Action at 4. Applicant respectfully traverses these rejections.

The Examiner contends that "*Kiang* teaches that single-walled carbon nanotubes, made by the arc-discharge process, tend to aggregate into bundles. The nanotubes in a bundle run substantially parallel to one another and appear to have uniform diameters (see Figure 2c). *Dresselhaus et al.* teach that the nanotube material produced by either laser vaporization or the

[1] *Dresselhaus* was published in 2001. The present application is a division of co-pending prior application Serial No. 10/000,746, filed on November 30, 2001, which is a continuation of prior application Serial No. 09/242,040 filed on September 13, 1999, which is the 35 U.S.C. § 371 national application of International Application Number PCT/US97/13896 filed on August 8, 1997, which designated the United States, claiming priority to provisional U.S. patent application Serial Number 60/023,732 filed on August 8, 1996. Thus, putting aside the benefits this application receives due to its provisional application, this application has at least an effective filing date of August 8, 1997. Accordingly, *Dresselhaus* is not prior art.

[2] As discussed in footnote 1, *Dresselhaus* is not prior art for the present Application. Furthermore, there are only three instances under which a second reference can be used when making a §102 rejection. *See* M.P.E.P § 2131.01. The only one possible pertinent here is the third instance, namely to "[s]how that a characteristic not disclosed in the reference is inherent." *Id.*

arc-discharge process appears as a mat of carbon bundles or ropes, such as those taught by *Kiang et al.* The single-walled nanotubes are arrayed in bundles aligned along a common axis; the bundles are then intertwined to form "ropes" (page 6). Additionally *Dresselhaus et al.* teaches that the bundles produced by the vaporization and the arc-discharge processes contain nearly perfect single-wall nanotubes of substantially uniform diameter (page 73). Therefore, it is inherent that the bundled single-walled nanotubes of *Kiang et al.* have a substantially uniform diameter." Office Action at 4.

As stated above, *Kiang* does not teach each and every limitation of base Claims 112 and 124, which recite "a substantially two-dimensional array comprising single-wall carbon nanotubes." Therefore, the asserted teachings of *Dresselhaus* pertaining to the inherency of substantially uniform diameters in nanotubes are inapposite. Thus, Claims 113, 115, 117, 119, 126, 128, 130, and 132 are not anticipated by, or rendered obvious over, *Kiang* as applied above contemplating the facts assertedly taught by *Dresselhaus*, for the same reasons base Claims 112 and 124 are not anticipated or rendered obvious. As a result of the foregoing, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 113, 115, 117, 119, 126, 128, 130, and 132 under 35 U.S.C. § 102(a) as being anticipated by *Kiang et al.* as applied above and with *Dresselhaus et al.*

III. REJECTIONS UNDER 35 U.S.C. § 102/103 OVER *KIANG*

Claims 113, 115, 117, 119, 126, 128, 130, 132 and 136-137 stand rejected under 35 U.S.C. § 102(a) as being anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over *Kiang et al.* Office Action at 4. Applicant respectfully traverses these rejections.

The Examiner contends that "*Kiang et al.* does not explicitly teach that the individual single-walled nanotubes in a bundle have homogeneous lengths or helicities in any given region of the bundle. However, it is expected that the tubes in a bundle will have the same helicity or the same length due to corresponding growth conditions. Thus it is expected that a nanotube bundle will have a homogeneous length or helicity. Furthermore, it is held that a nanotube must be of the (n, n) or (m, n) helicity index. A mix is expected to occur due to what is known about

growth conditions; bundles of predominantly (n, n) as well as bundles of predominantly (m, n) are therefore expected to occur." Office action at 4-5.

As stated above, *Kiang* does not teach each and every limitation of base Claims 112 and 124 which recite "a substantially two-dimensional array comprising single-wall carbon nanotubes." In addition, for inherency to be shown, extrinsic evidence must be presented that makes "clear that the missing descriptive matter is ***necessarily*** present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Continental Can Co. v. Monsanto Co.*, 948 F.2d 1264, 1268, 20 U.S.P.Q.2d 1746, 1749 (Fed. Cir. 1991) (emphasis added). Inherency cannot be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is legally insufficient. *Id.*, 948 F.2d at 1269, 20 U.S.P.Q.2d at 1749. Thus, the Examiner's assertions as to what phenomena are "expected" with regard to tube helicity and length are not sufficiently supported to establish inherency. As a result of the foregoing, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 113, 115, 117, 119, 126, 128, 130, 132 and 136-137, depending from base claims 112 and 124, under 35 U.S.C. § 102(a) as being anticipated by, or in the alternative under 35 U.S.C. § 103(a) as being obvious over, *Kiang* as applied above.

IV. REJECTION UNDER 35 U.S.C. § 103 OVER *KIANG* IN VIEW OF *HIURA* WITH *SEN*

Claim 120 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over *Kiang,* as applied above, and further in view of *Hiura et al.*, United States Patent No. 5,698,175 ("*Hiura*") with *Sen et al.*, "Structures and Images of Novel Derivatives of Carbon Nanotubes, Fullerenes and Related New Carbon Forms," *Fullerene Science and Technology*, Vol. 5 (3), pp. 489-502, 1997, ("*Sen*") to show a "state of fact." Office Action at 5. Applicant respectfully traverses this rejection.

The Examiner contends "*Kiang* does not teach bundles containing a single-wall nanotube having a substituent on the end. *Hiura* teaches a process for the purification of carbon nanotubes. The process comprises treating the nanotubes with an aqueous oxidizing agent, such as nitric acid, in solution. The nanotubes are dispersed into the solution and heated in order to

selectively react the carbon impurities to dissolve in the liquid phase. The nanotubes are then separated from the liquid by filtering, washing, and drying. *Hiura* does not explicitly teach the process be used for the purification of single-walled nanotubes, however, it would have been obvious to one of ordinary skill at the time of invention to apply the treatment of *Hiura* on a sample containing bundles of single-walled nanotubes, in order to remove impurities. *Sen et al.* teaches that when nanotubes are reacted with nitric acid or other oxidizing agents, such reactions are known to result in the functional groups, especially –COOH, at the tips (page 493). Substituent groups inherently exist on the ends of nanotubes treated by the process of *Hiura et al.*" Office Action at 5,

As stated above, *Kiang* does not teach or suggest each and every limitation of base Claim 112 which recites "a substantially two-dimensional array comprising single-wall carbon nanotubes," nor is a substantially two-dimensional array taught or suggested by *Hiura*. Furthermore, *Hiura* describes the formation and manipulation of multi-wall nanotubes, not single-wall nanotubes (*See*, *e.g.*, col. 3, *ll.* 12-28, wherein *Hiura* states there are "pentagons and hexagons (six-membered carbon rings) which are included in graphite comprising the outer wall of carbon nanotubes. It is generally known that pentagons are more reactive than hexagons. Carbon nanotubes have outer walls closed by a graphite layer, containing only hexagons in the side walls of the outer walls and containing in total twelve pentagons other than hexagons in both edge portions of the outer walls, i.e. tips of the carbon nanotubes. Therefore, the pentagons contained in the tips of the carbon nanotubes is [sic] likely to selectively accept the attack by the reaction reagent such as sulfuric acid, nitric acid or the like. Because of this, the pentagons first start splitting. Along with the splitting of the pentagons, the hexagons adjacent to the pentagons gradually start splitting while extending the split portion. Furthermore, the splitting reaction proceeds, to a graphite lower layer which constitutes a carbon nanotube.")

The distinction between single-wall and multi-wall carbon nanotubes is important because multi-wall carbon nanotubes are fundamentally different from single-wall carbon nanotubes. Single-wall carbon nanotubes are molecules of carbon, while multi-wall carbon nanotubes are assemblies of carbon. The structural differences between single-wall and multi-

wall carbon nanotubes lead to differences in physical and chemical properties, such as tensile strength, modulus, flexibility, thermal conductivity, electrical conductivity, chemical reactivity and chemical stability. As a result of such differences, the chemistry that can be performed with single-wall carbon nanotubes is quite different from that obtainable with multi-wall carbon nanotubes, and the reactivity of the latter would not be an accurate predictor of the reactivity of the former. Thus, it would not have been obvious to one of ordinary skill in the art to apply the processes of *Hiura* to the single-wall carbon nanotubes described by *Kiang*. Moreover, *Kiang et al.* acknowledge the breaking ("splitting") of carbon-carbon bonds that result from the application of their purification methods to multi-wall carbon nanotubes. As such multi-wall carbon nanotubes are typically riddled with defects, such splitting likely occurs at regions on the walls as well as the tips. As will be appreciated by one of skill in the art, such bond splitting leads to nanotube destruction. Hence, not only would the teachings of *Hiura* not have suggested a reasonable likelihood of success as applied to single-wall carbon nanotubes, in fact such a chemical protocol actually fails to achieve the desired results. Importantly, the functionalization of carbon nanotubes disclosed by *Sen* involves only single-wall nanotubes. (*See, e.g.*, Figures 3-4) In light of the forgoing, Applicant contends that Claim 120, depending from Claim 112, is not obvious and respectfully requests the Examiner withdraw the rejection of Claim 120 under 35 U.S.C. § 103(a) as being unpatentable over *Kiang et al.* as applied above in view of *Hiura* with *Sen et al.*

V. REJECTION UNDER 35 U.S.C. § 103 OVER *KIANG* IN VIEW OF *GREEN*

Claims 121 and 133 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Kiang,* as applied to Claim 112 above, and further in view of *Green et al.,* United States Patent No. 6,090,363 ("*Green*").

The Examiner contends "*Green* teaches a process whereby the nanotubes are treated and purified in nitric acid. Green additionally teaches that materials, such as a variety of metals, may be endohedrally added to the nanotubes during the purification process. *Green et al.* does not explicitly teach that the process be used for the purification of single-wall carbon nanotubes,

however it would have been obvious to one of ordinary skill at the time of invention to perform the treatment of *Green et al.* on a sample containing bundles of single walled nanotubes, in order to remove impurities and introduce endohedral species." Office Action at 6.

As stated above *Kiang* does not teach or suggest each and every limitation of base Claims 112 and 124 which recite "a substantially two-dimensional array comprising single-wall carbon nanotubes," nor is a substantially two-dimensional array taught or suggested by *Green*. Thus, Claims 121 and 133, depending from base Claims 112 and 124, respectively, are not obvious. In light of the forgoing, Applicant respectfully requests the Examiner withdraw the rejection of Claims 121 and 133 under 35 U.S.C. § 103(a) as being unpatentable over *Kiang* in view of *Green*.

VI. ALLOWABLE SUBJECT MATTER

The Examiner indicated that Claim 141 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Office Action at 6.

Regarding Claim 141, Applicant does not concede that Claim 141 as previously presented is unpatentable over the cited references; however, this claim has been amended and rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The Examiner has indicated Claims 125, 134-135, 138-140 are allowed. Office Action at 6.

Regarding Claim 138, this claim has been rewritten in independent form.

VII. CONCLUSION

As a result of the foregoing, it is asserted by Applicant that the claims in the Application are now in condition for allowance, and respectfully request allowance of such claims.

Applicant respectfully requests that the Examiner call Applicant's attorney at the below listed number if the Examiner believes that such a discussion would be helpful in resolving any remaining problems.

Respectfully submitted,

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